Rootstock-dependent response of Hass avocado to salt stress

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Wide range of plant responses to salinity

Molecular level

- Nucleic acid degradation
- Gene methylation
- Lipid oxidation
- Enzyme inactivation
- Protein denaturation

Cellular level

- Cell-wall degradation
- Membrane rigidification
- Electrolyte leakage
- Ionic imbalance
- Oxidative stress

Physiology

- CO_2 assimilation
- Stomatal conductance
- Transpiration
- Water potential
- Water uptake
- Nutrient uptake

Development

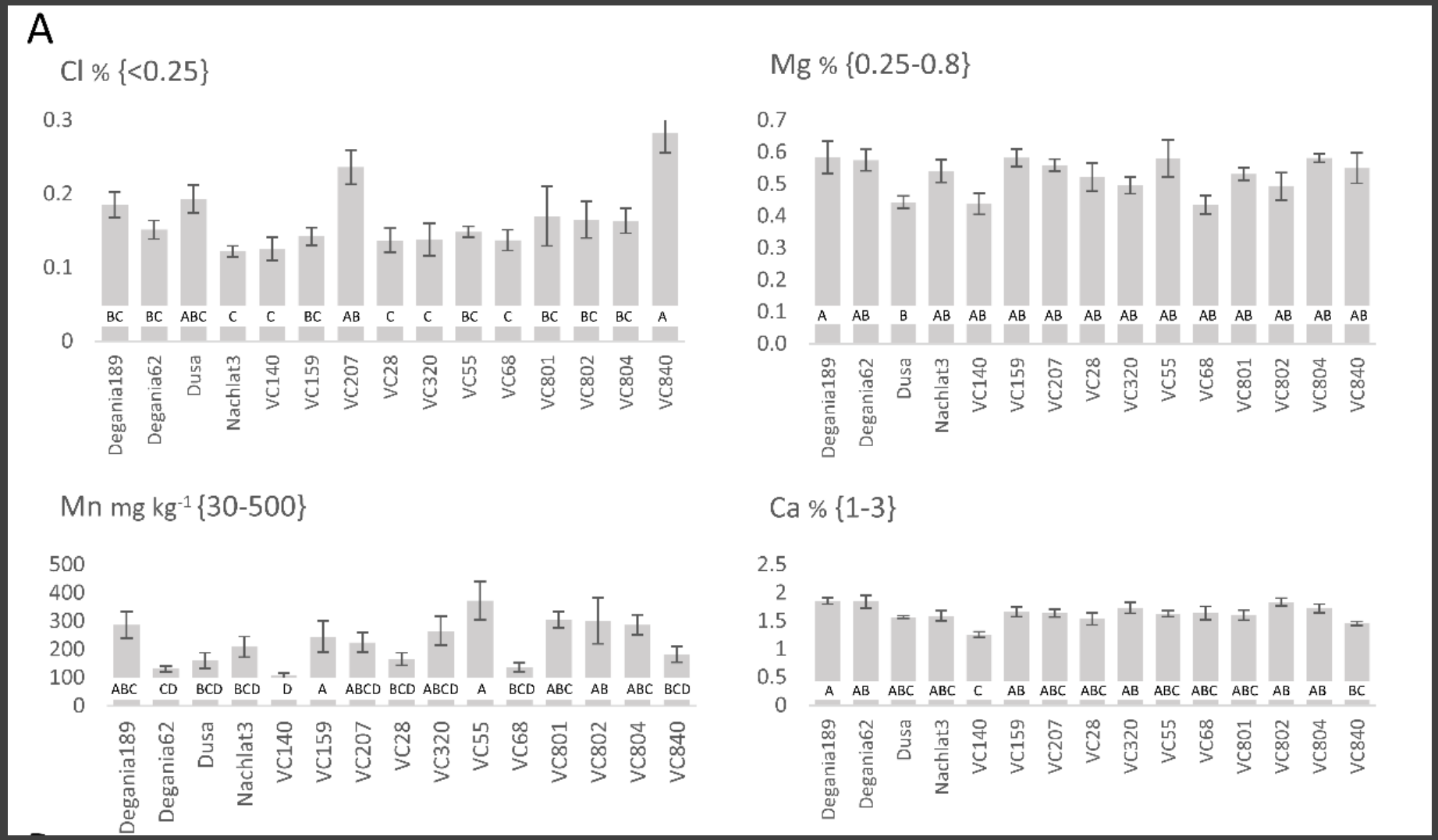
- Germination
- Vegetative growth
- Reproduction
- Yield

The Experimental Orchard, Gilat

RS	Race	Propagation method	Origin
VC26	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC27	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC28	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC55	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC66	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC68	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC96	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC140	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC152	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC159	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC162	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC207	W.I.×Mex.	Clonal	U.S.
VC320	W.I.	Clonal	Kaiima Bio Agritech; Israel
VC801	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC802	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC804	W.I.	Clonal	A. Ben-Ya'acov collection; Israel
VC840	Mex.	Clonal	A. Ben-Ya'acov collection; Israel
Latas	Mex.×Gu.	Clonal	Westfalia Fruit; South Africa
Dusa	Mex.×Gu.	Clonal	Westfalia Fruit; South Africa
Waldin	W.I.	Seed	U.S.
Degania 62	W.I.	Seed	A. Ben-Ya'acov collection; Israel
Degania 189	W.I.	Seed	A. Ben-Ya'acov collection; Israel
Nachlat 3	W.I.	Seed	A. Ben-Ya'acov collection; Israel

H	H	E	H	H	H

The effect of the rootstock on mineral level in avocado leaves, fresh water



Lazare *et al*. 2019

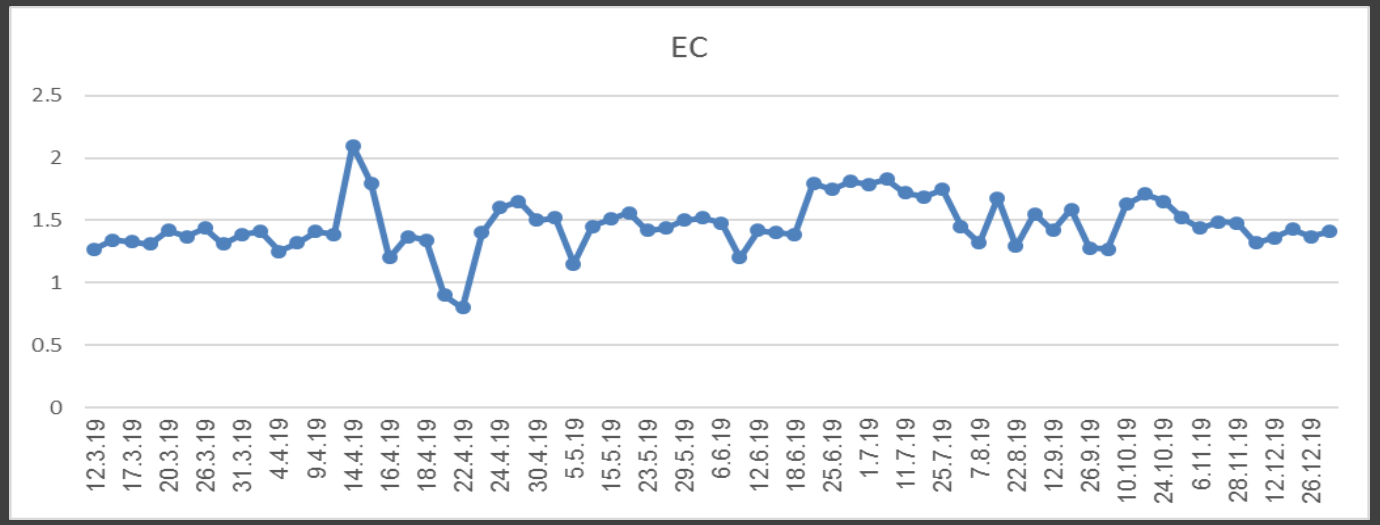
Comparison of foliar mineral contents in 'Hass' and 'Ettinger', grafted on rootstocks of different genetic origin fresh water

	Hass		Ettinger	
	Genetic origin			
	Mexican	West Indian	Mexican	West Indian
N (%)	0.07±1.46	0.11±1.41	0.12±1.47	0.12±1.43
P (%)	0.01±0.12	0.02±0.12	0.01±0.10	0.01±0.11
K (%)	0.08±0.87	0.12±0.88	0.10±0.78	0.11±0.82
Cl (%)	**0.06±0.24**	0.04±0.15	**0.05±0.22**	0.04±0.15
Na (%)	0.005±0.011	0.005±0.012	0.004±0.011	0.002±0.011
B (mg kg^{-1})	19.08±114.75	19.31±121.52	16.43±89.35	19.42±97.33
Ca (%)	0.12±1.55	0.24±1.65	0.16±1.45	0.25±1.49
Mg (%)	0.06±0.54	**0.09±0.60**	0.08±0.51	0.09±0.53
Mn (mg kg^{-1})	69.16±190.57	**129.47±274.11**	69.51±192.27	116.67±230.45
Fe (mg kg^{-1})	23.39±127.57	41.15±136.86	22.88±117.72	41.00±124.17
Cu (mg kg^{-1})	0.62±5.96	0.69±5.63	0.84±5.63	0.83±5.41

Lazare *et al*. 2019

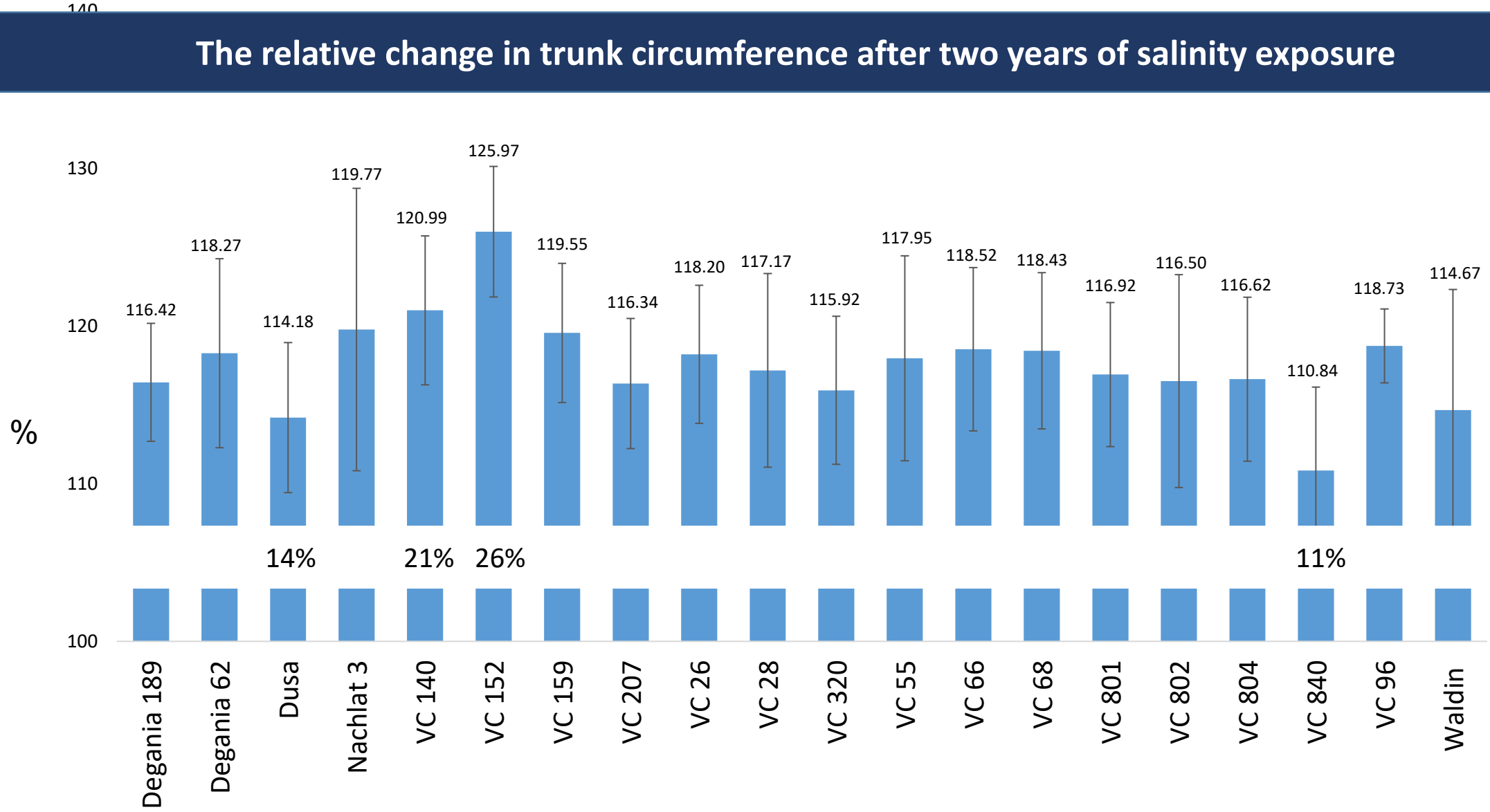
Since 7.3.2019, the orchard is fertigated with NaCl addition (280 mg/L)

Tap water: 30-40 ppm Cl | Target irrigation water: 280 ppm Cl



Date	EC	Cl , ppm
4.4.19	1.25	282
15.4.19	1.8	291
5.5.19	1.15	236
13.6.19	1.35	273

The relative change in trunk circumference after two years of salinity exposure



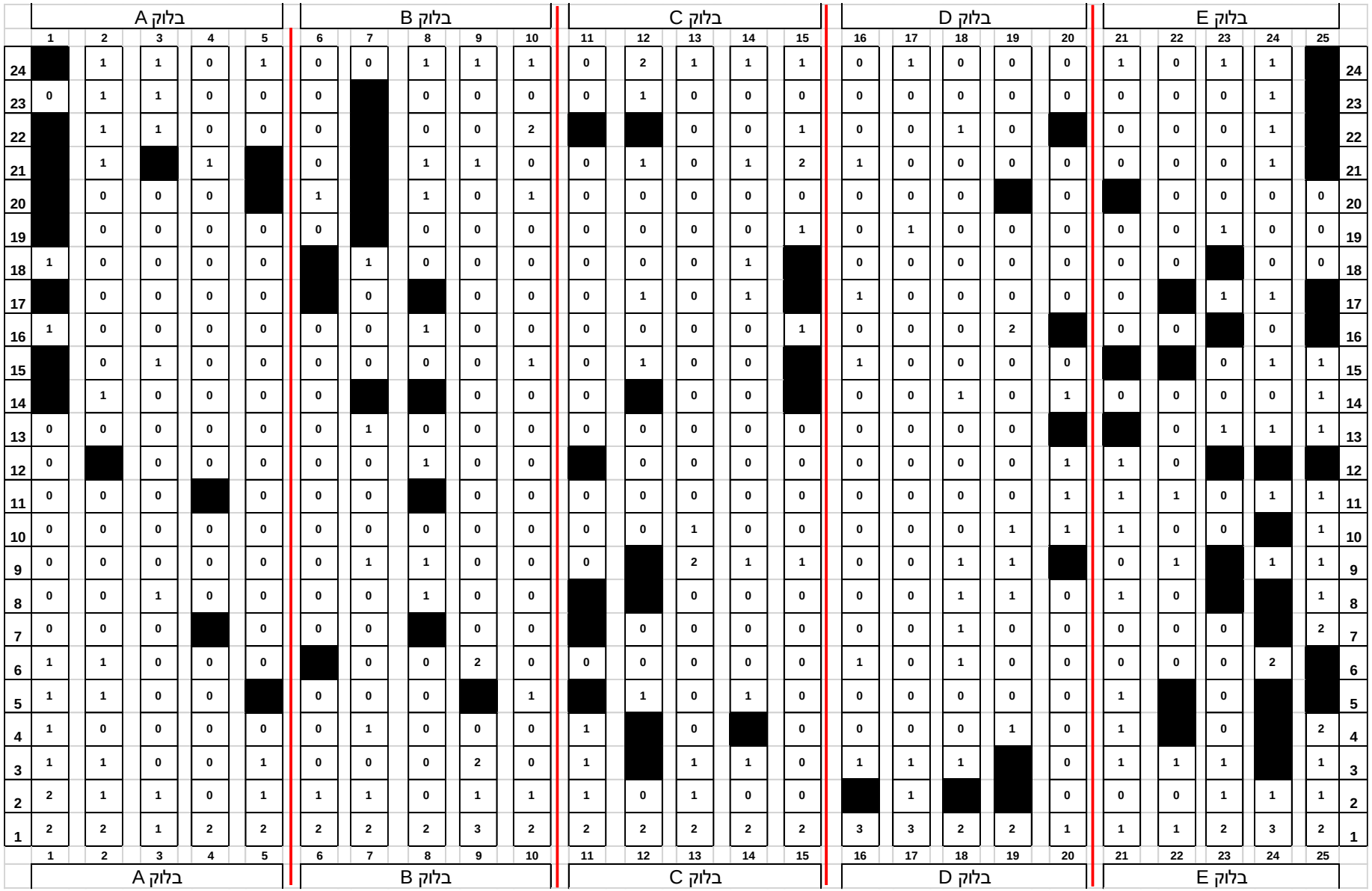
Hass

Lazare *et al*. 2021

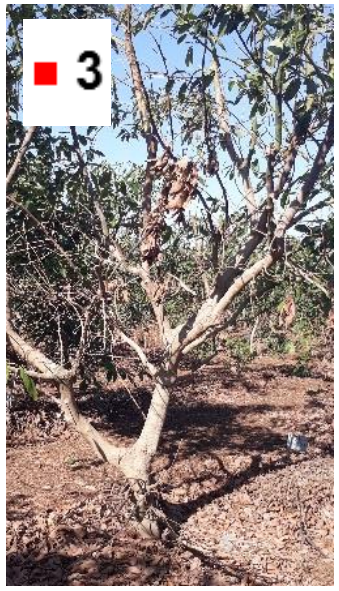
Salinity damages survey

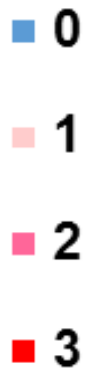


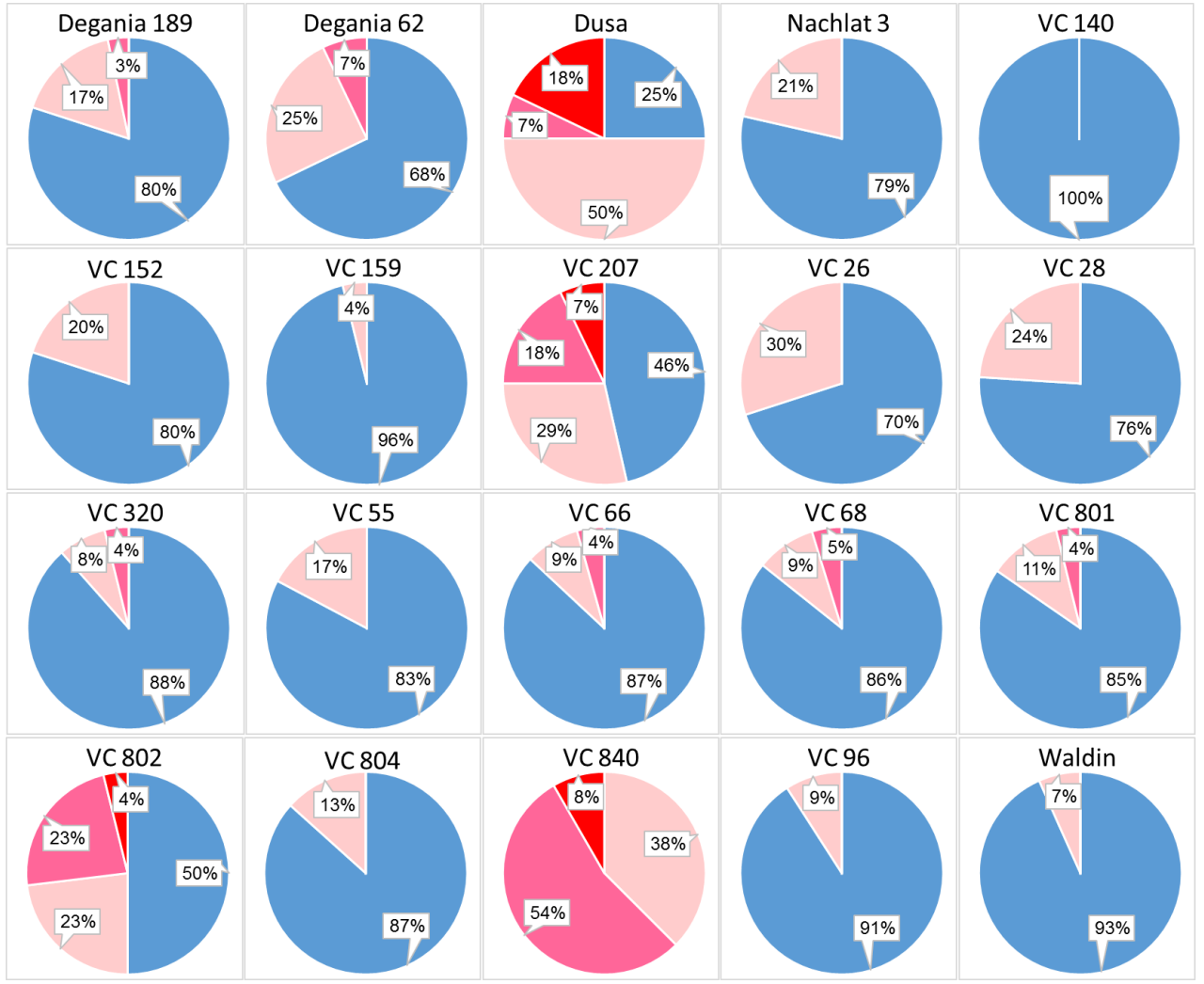
Salinity damages survey



Salinity damages survey

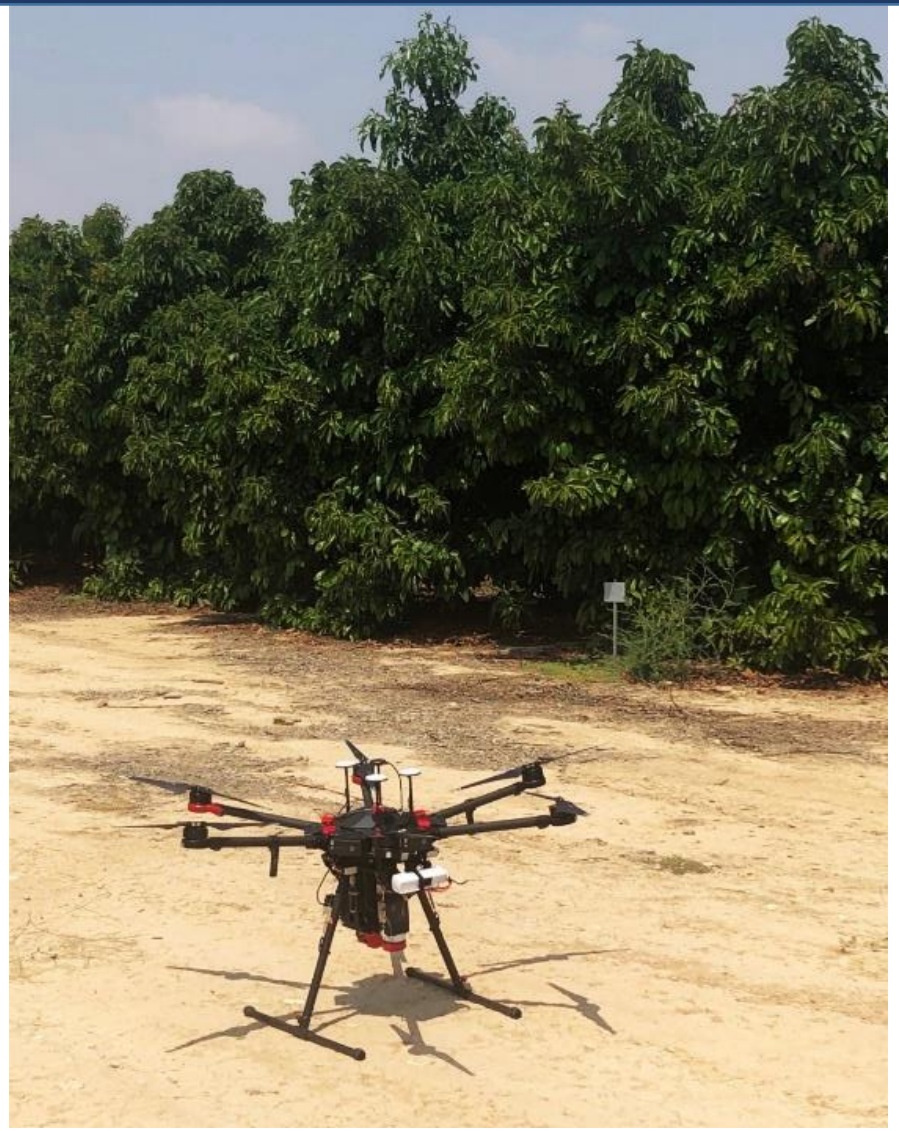


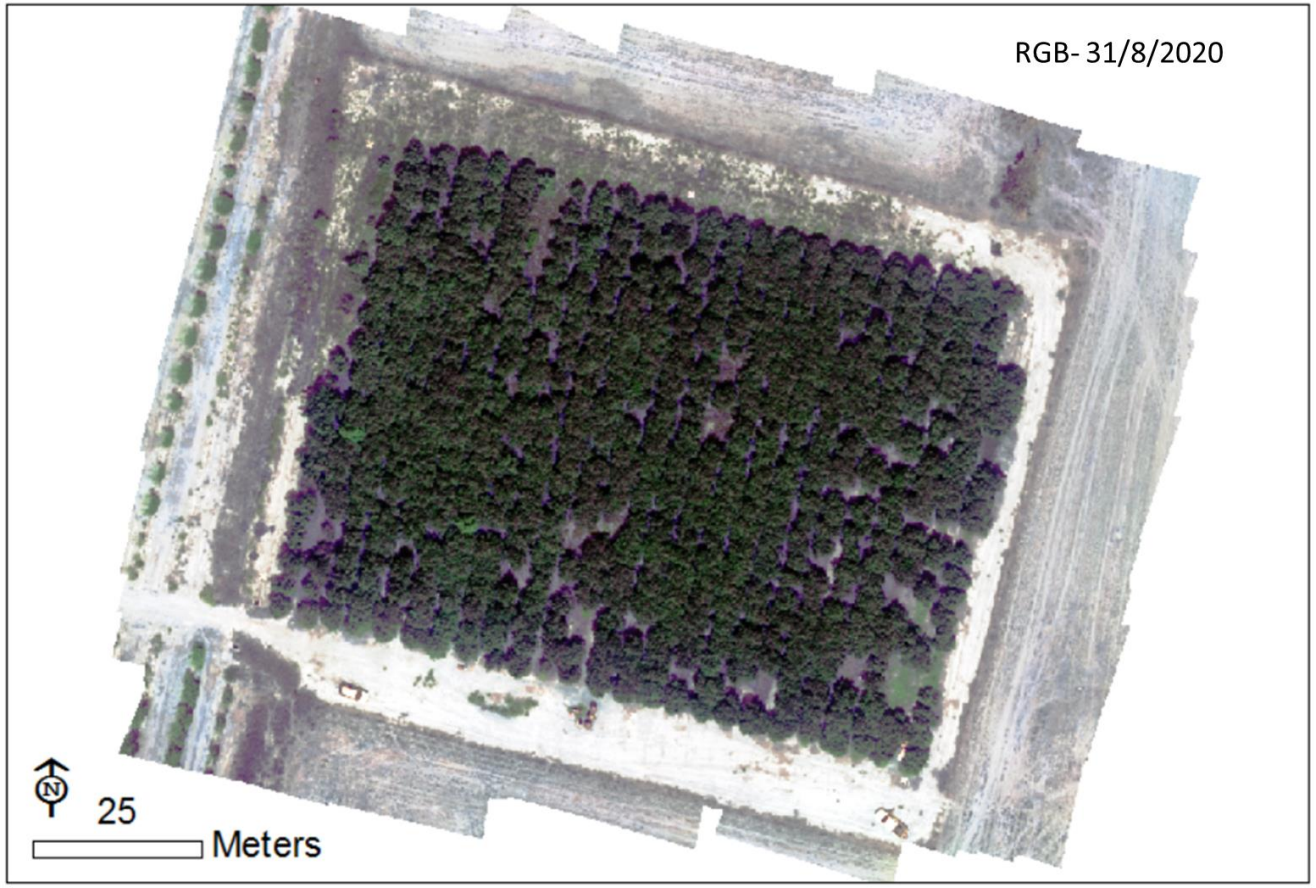




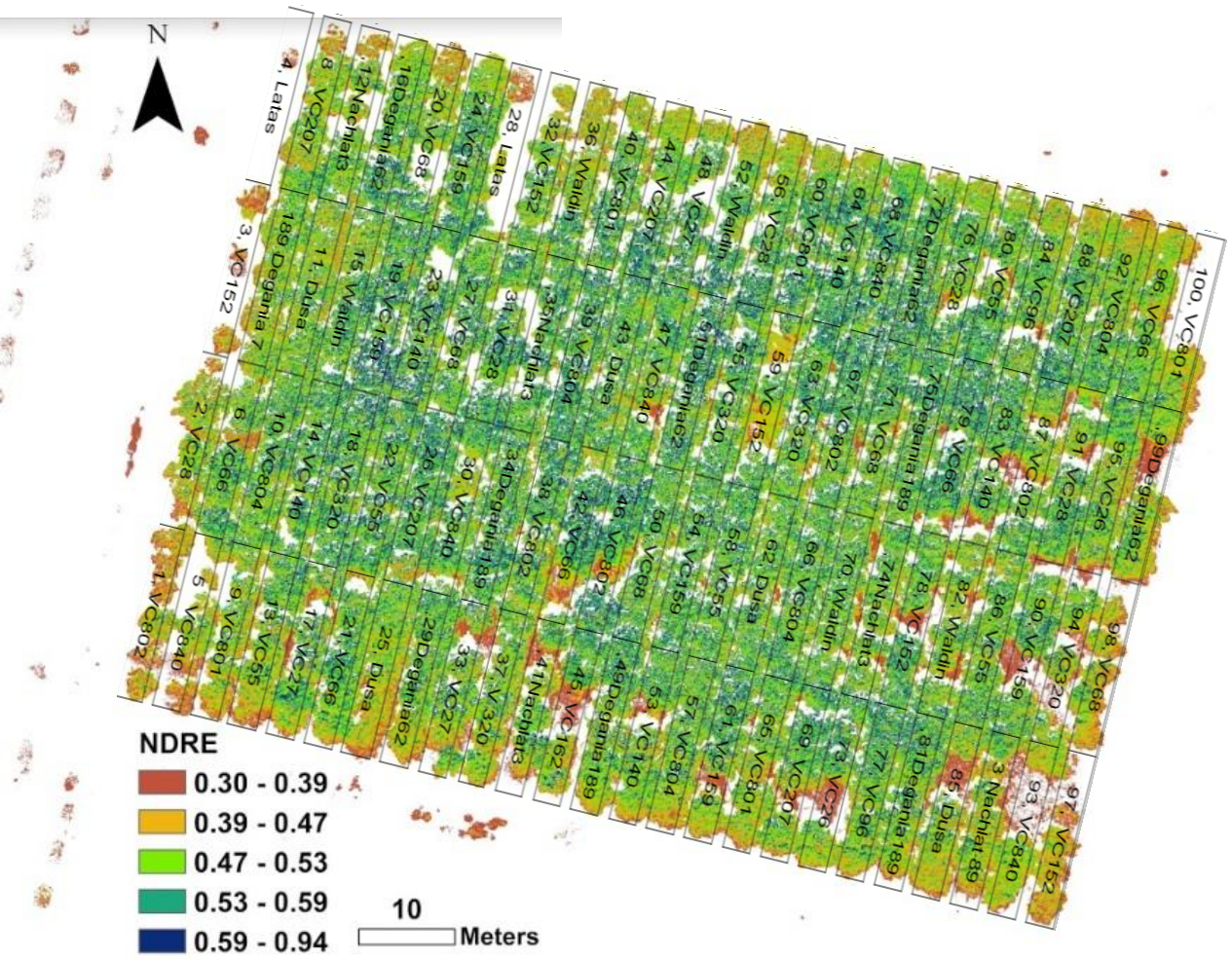
Lazare *et al*. 2021

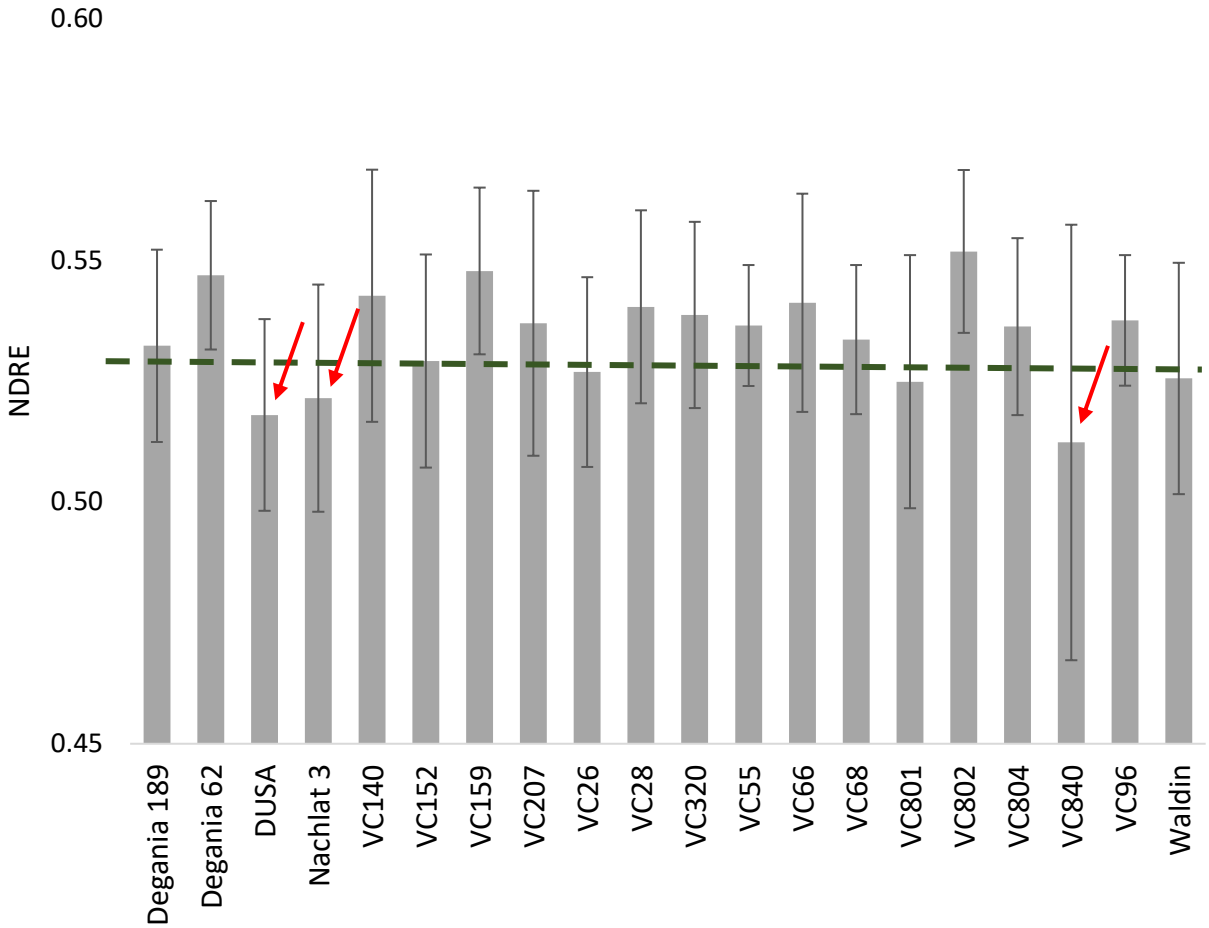
Remote sensing - stress indication





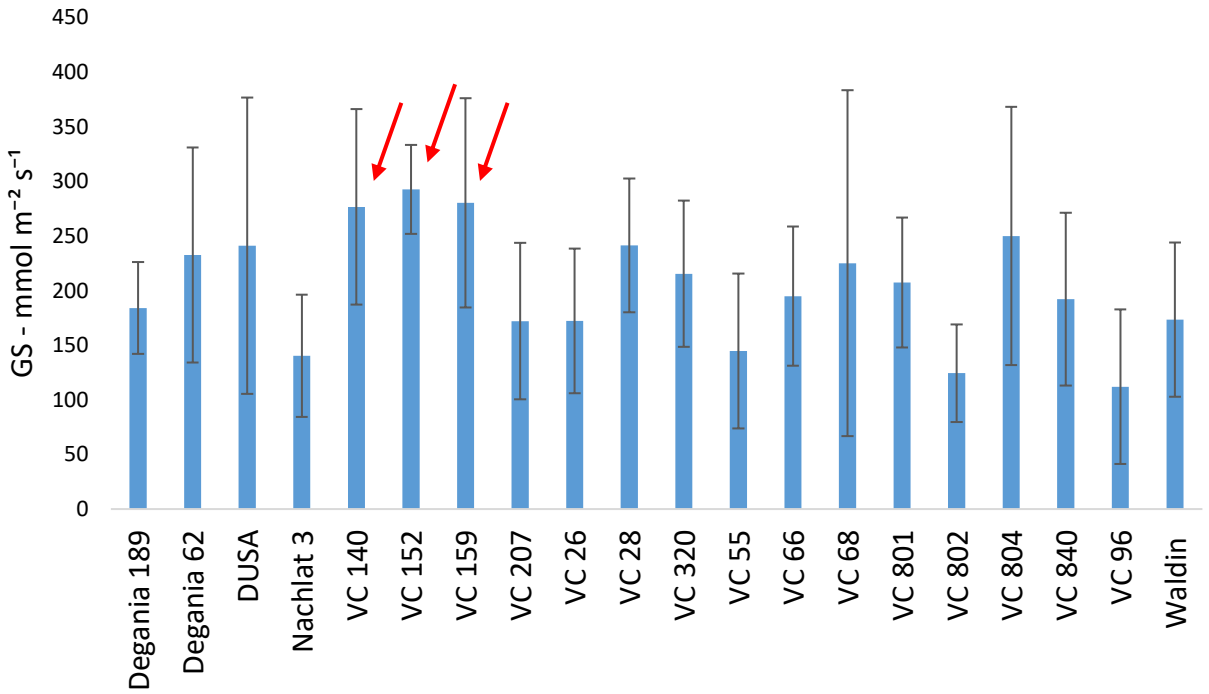
Remote sensing - stress indication



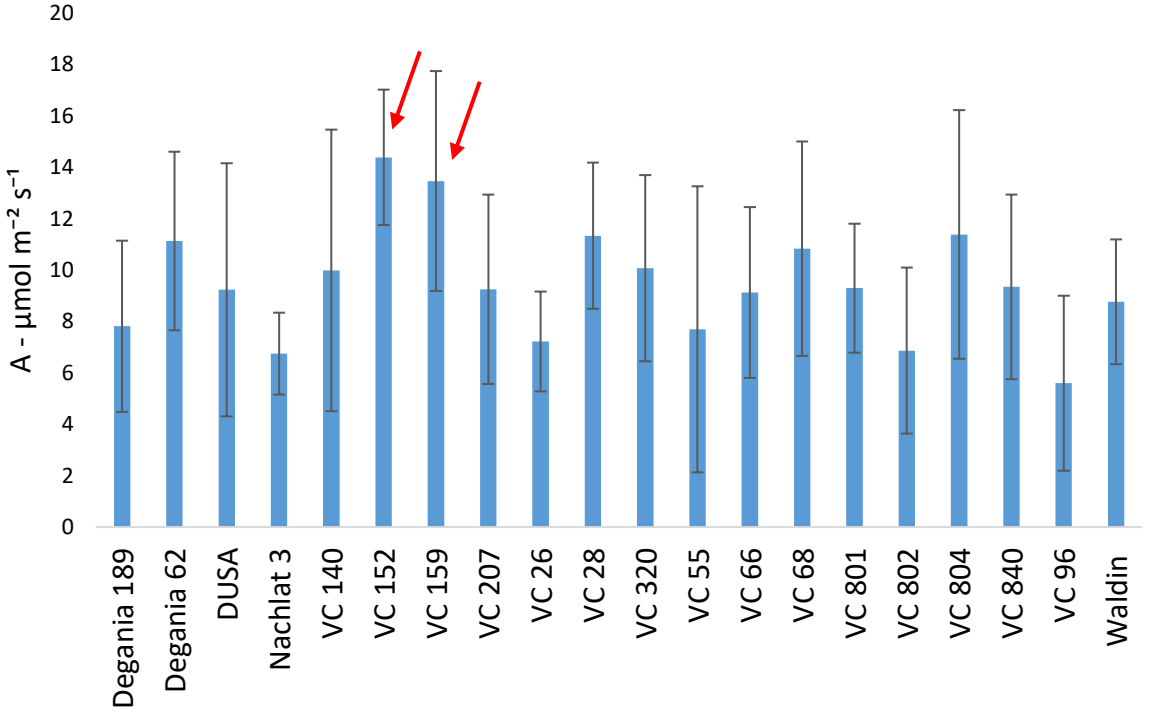


Lazare *et al*. 2021

Stomatal conductance



CO_2 assimilation



Hass

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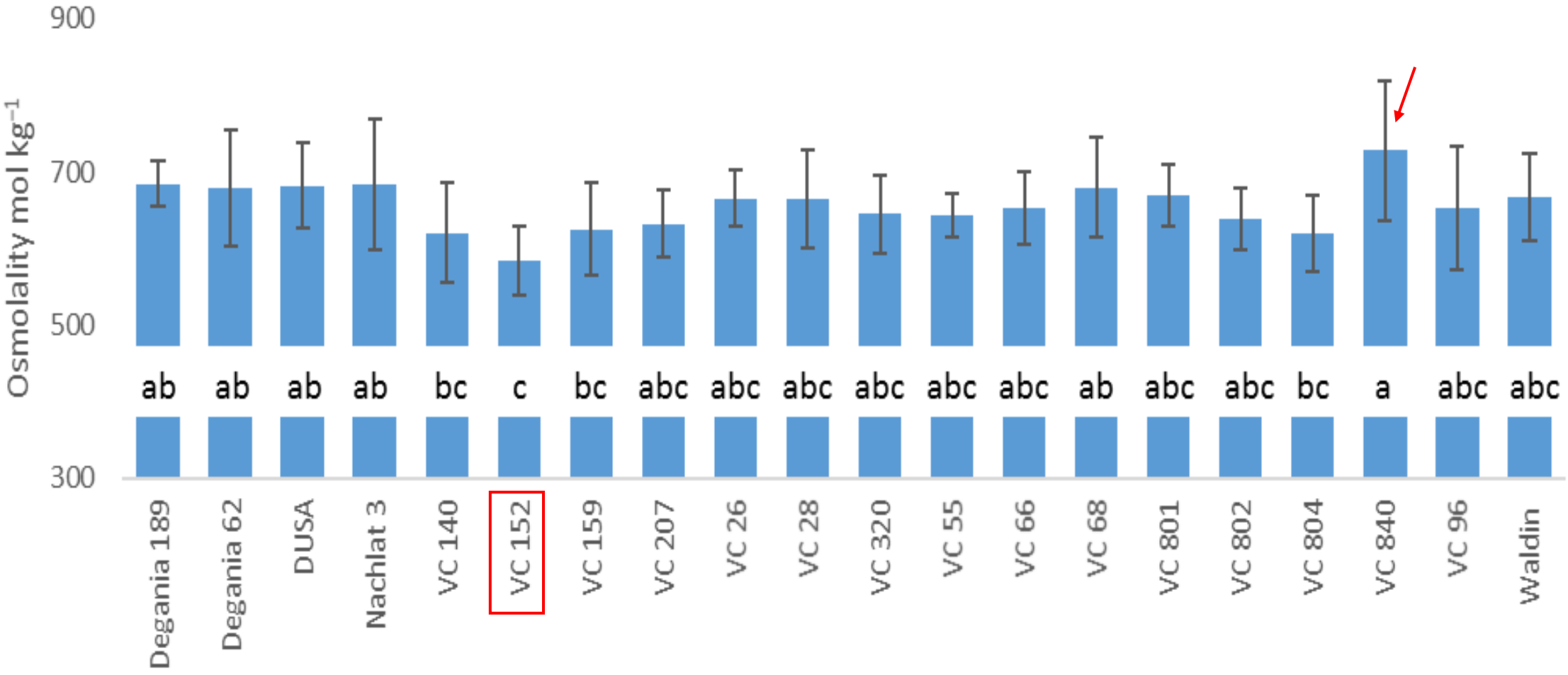
Leaf osmolality



Hass

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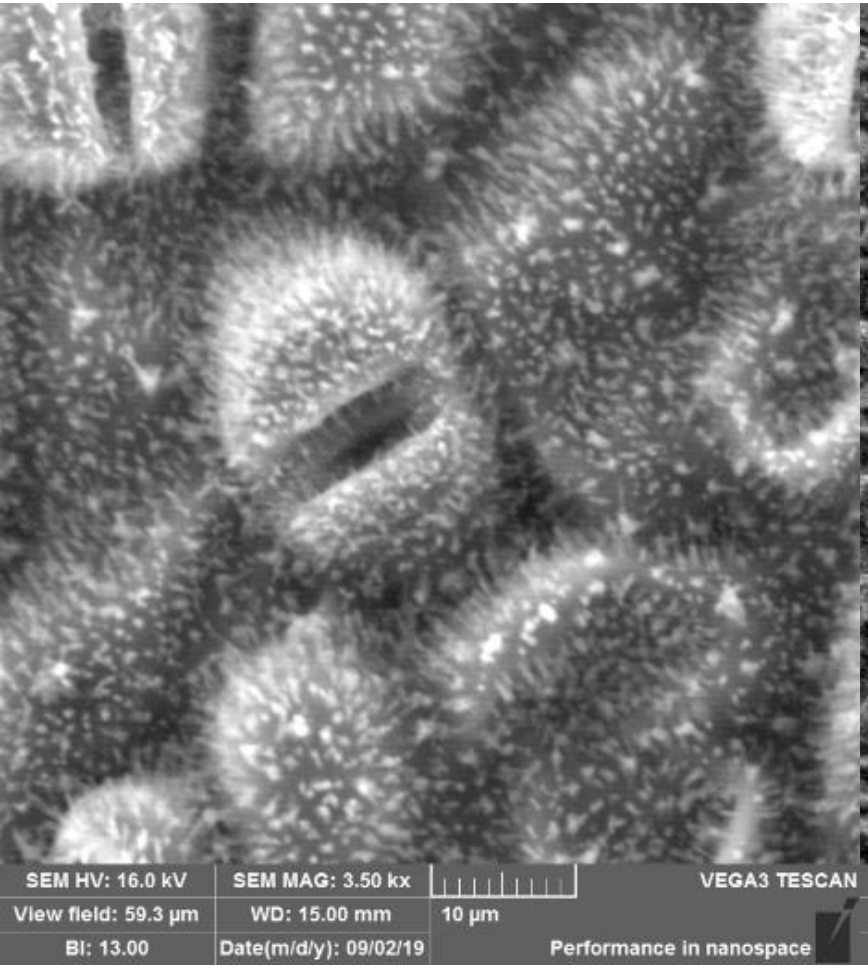
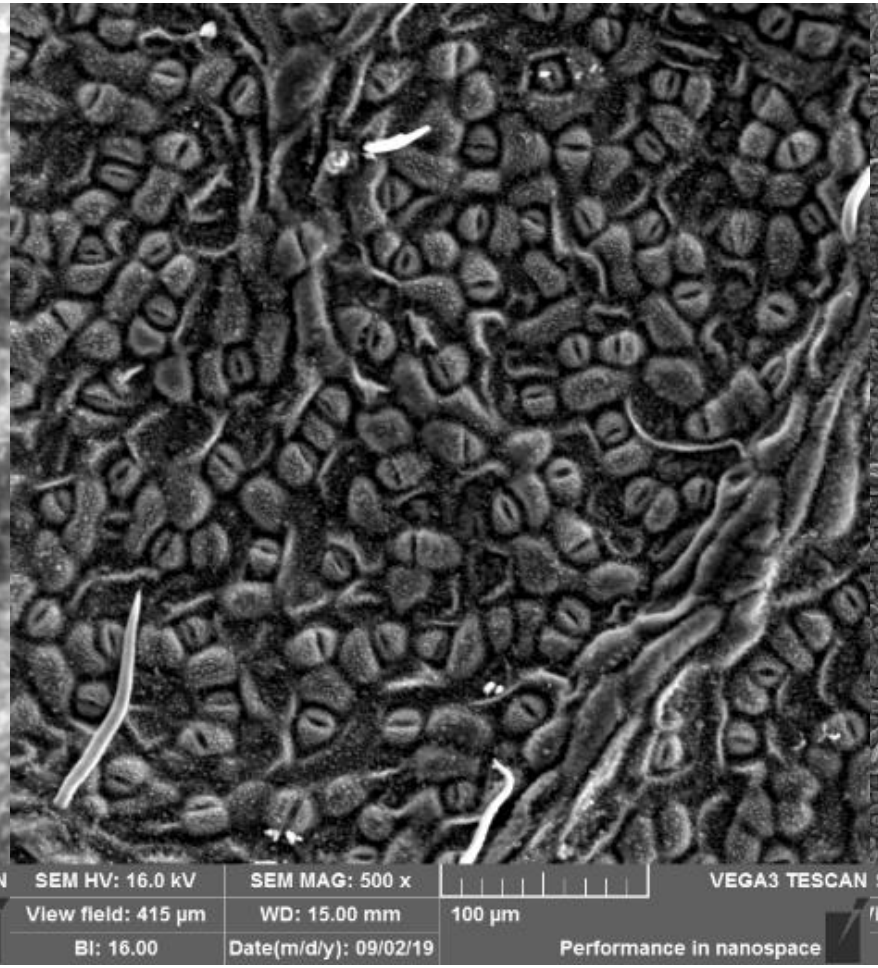
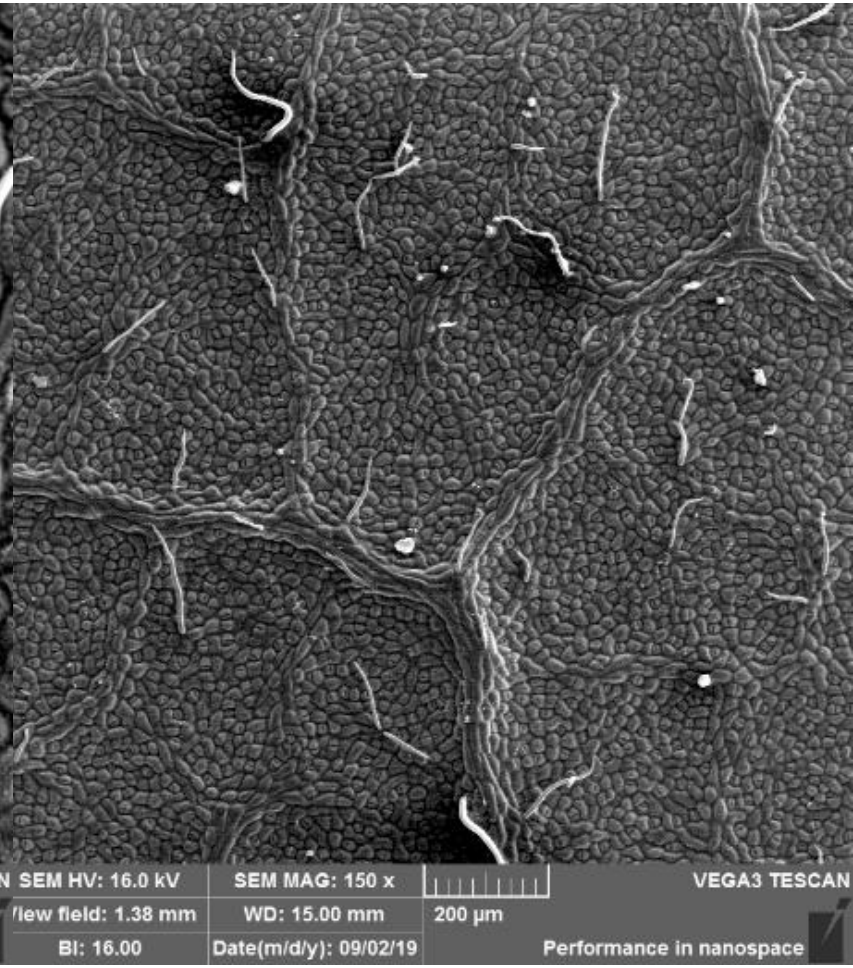
The avocado leaf’s abaxial side- SEM



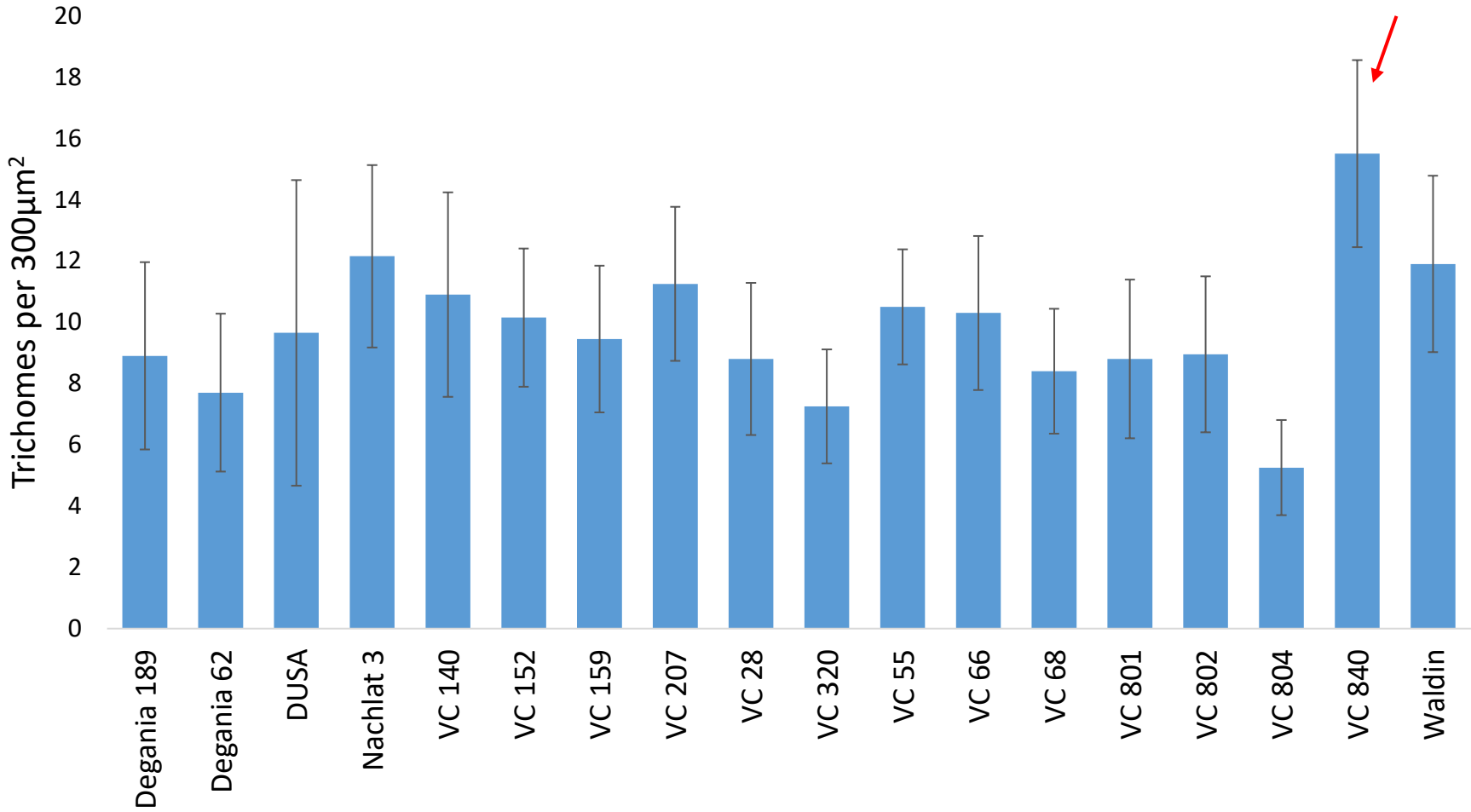




Hass

The avocado leaf’s abaxial side- Stereoscope

Trichome density



Lazare *et al*. 2021

Fruit per tree after 3 years of salinity exposure (2021 yield)

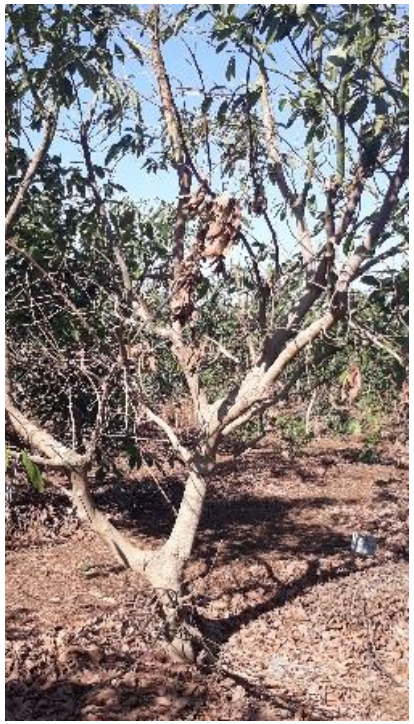
RS	FPT
VC159	262.3
Nachlat3	218.0
VC26	194.3
VC68	188.3
VC96	188.1
VC152	173.1
VC320	169.8
DEG189	167.7
VC801	151.9
DEG62	125.4
VC66	124.4
Waldin	114.7
VC28	108.4
VC55	107.7
DUSA	103.0
VC140	88.9
VC802	88.7
VC207	75.2
VC840	69.9
VC804	65.4

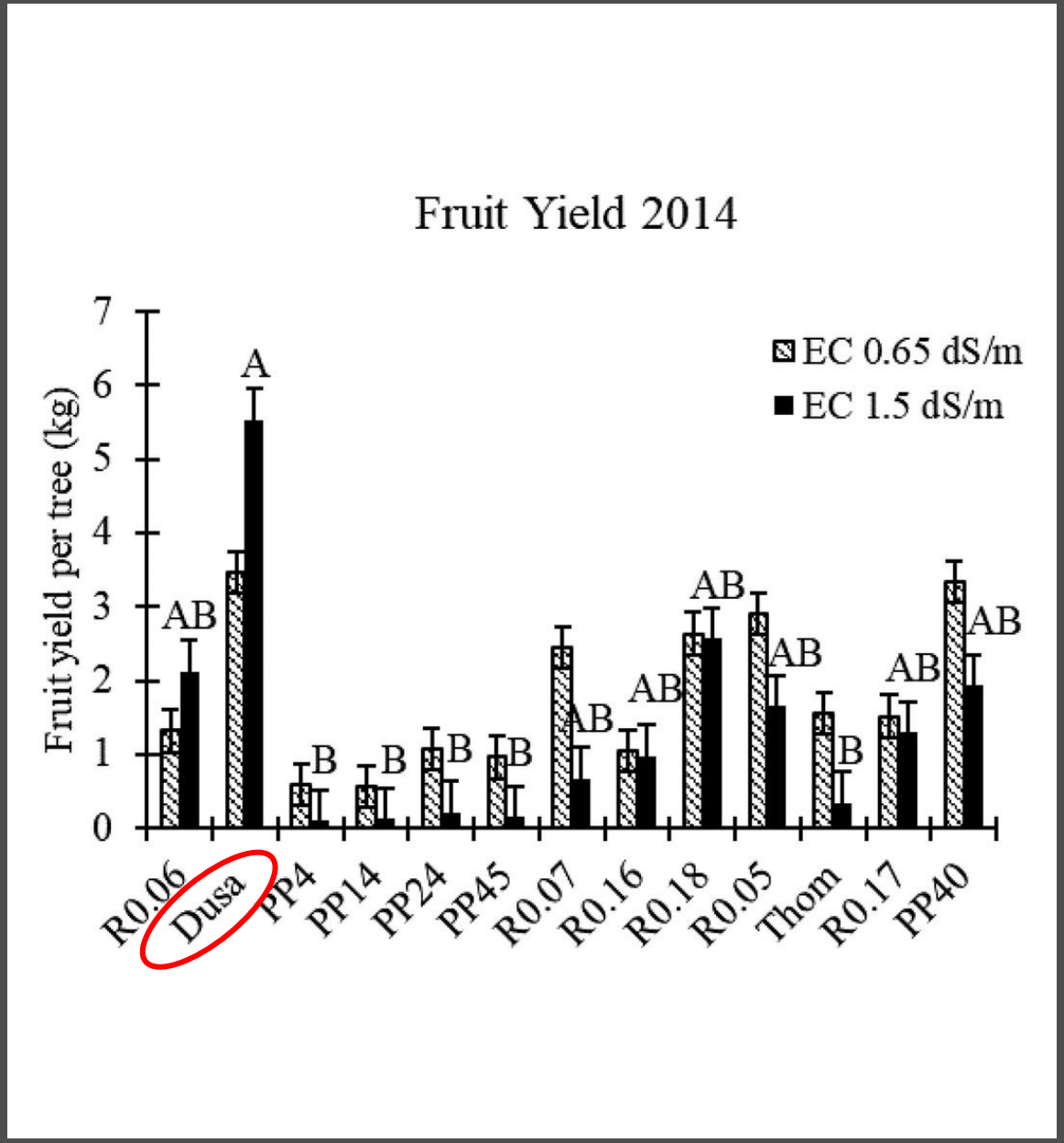
Hass

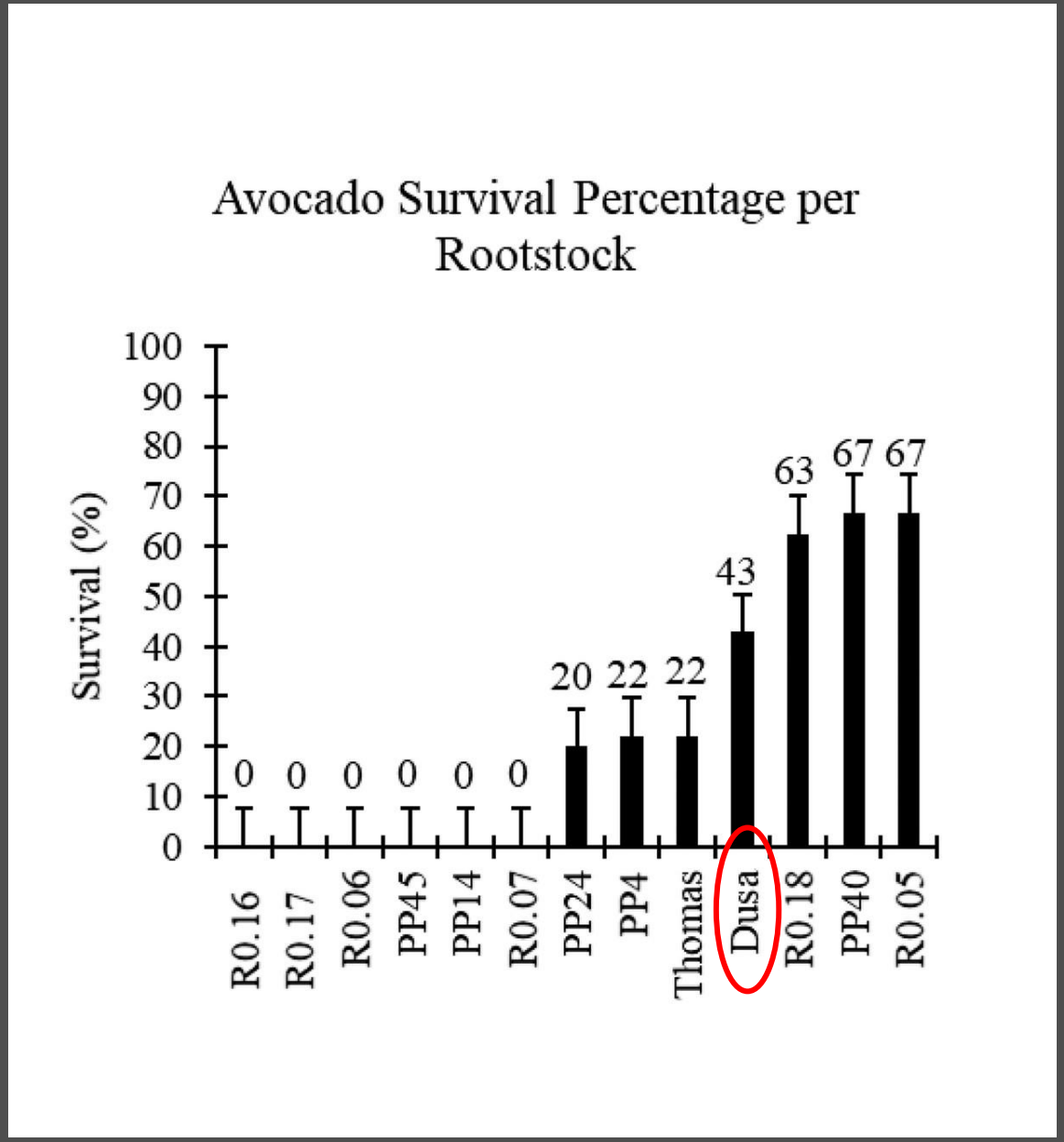
Salinity susceptibility rate, EC = 1.4-1.5 dS/m

Rootstock	Final score
VC 840	17.0
DUSA	15.1
VC 802	15.0
VC 207	13.0
Degania 189	12.5
Waldin	12.5
VC 801	12.4
Nachlat 3	11.4
VC 55	11.3
VC 26	10.5
VC 66	10.1
VC 28	9.6
Degania 62	9.4
VC 96	9.1
VC 68	8.1
VC 804	7.4
VC 320	7.1
VC 140	6.5
VC 152	6.0
VC 159	4.6

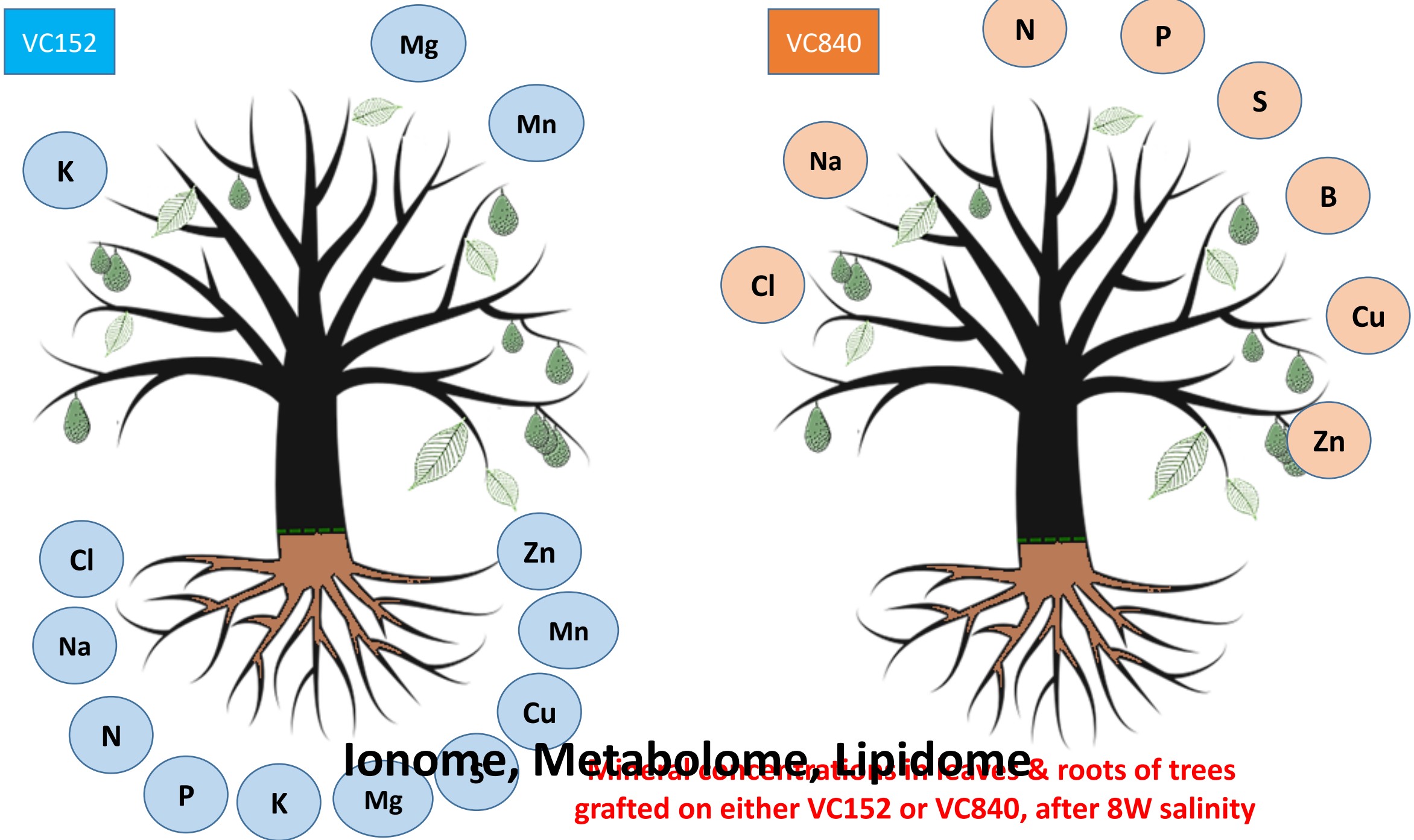
Less susceptible ← → More susceptible







Celis, N., Suarez, D. L., Wu, L., Li, R., Arpaia, M. L., & Mauk, P. (2018) *HortScience*

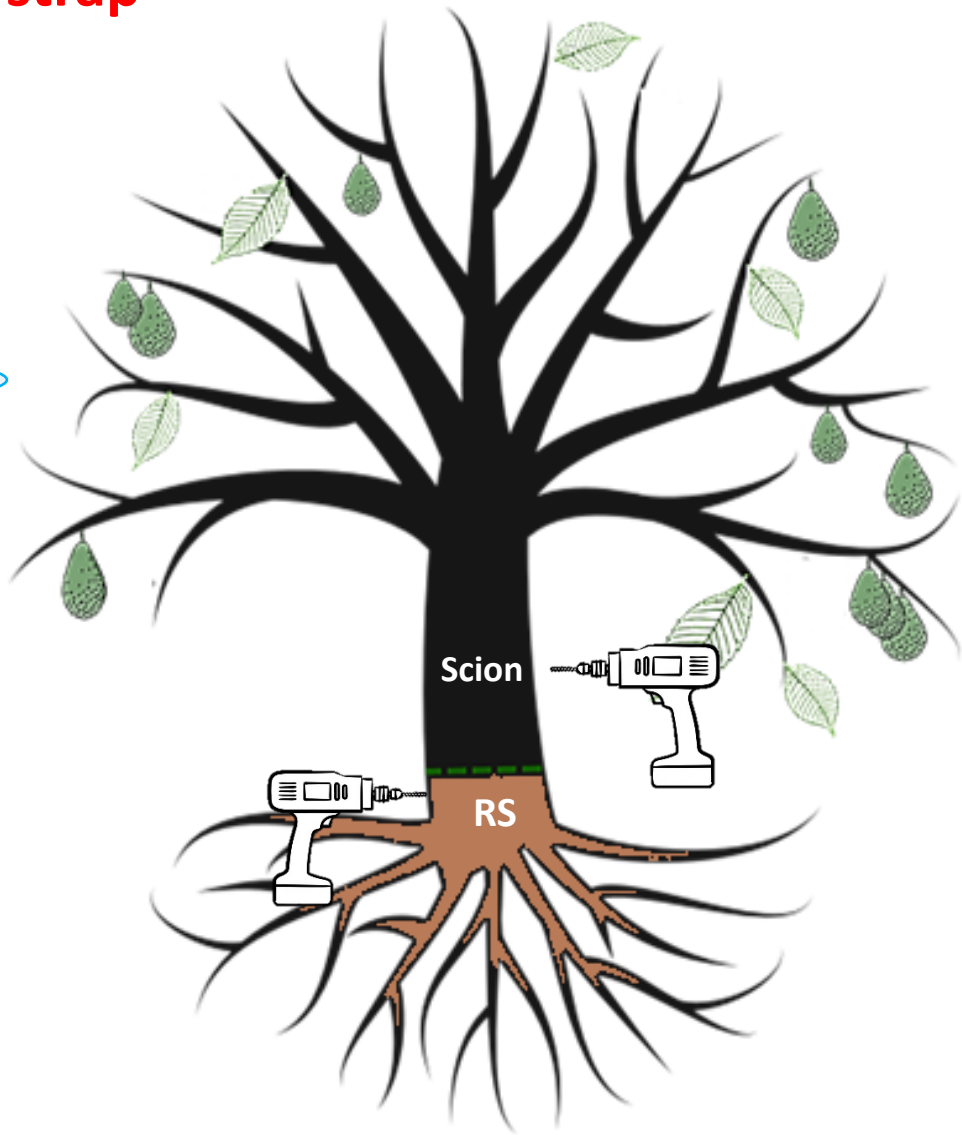


Ionome, Metabolome, Lipidome

Mineral concentrations in leaves & roots of trees grafted on either VC152 or VC840, after 8W salinity

The mineral concentrations of avocado trunks 5 cm below (RS) and 15 cm above (scion) the grafting strap

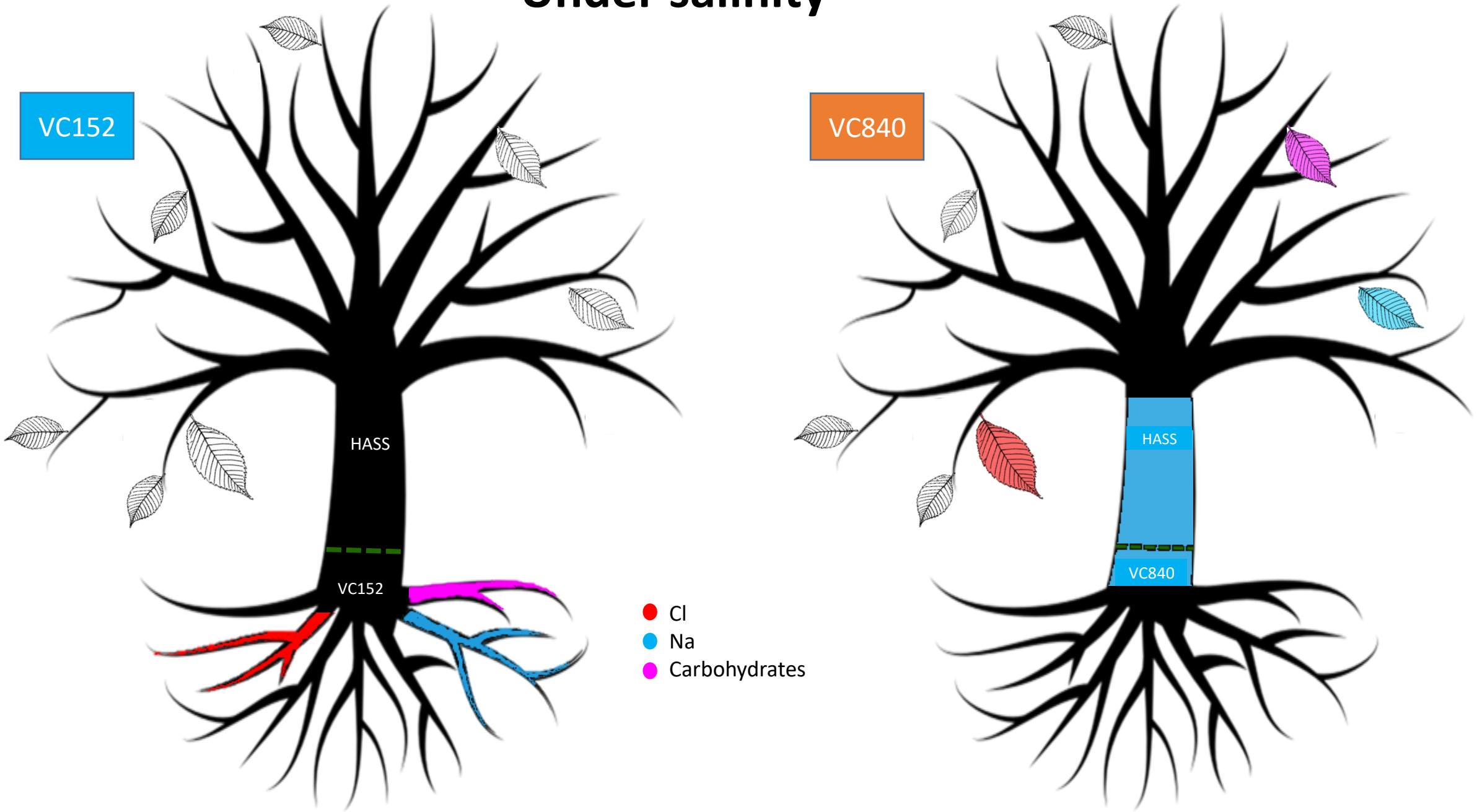
	VC152		VC840	
	RS	Scion	RS	Scion
Cl,%	0.08	0.06	0.07	0.07
Na%	**0.04**	0.01	0.19	**0.26**
N,%	0.30	0.25	0.22	0.24
P%	0.04	0.05	0.04	0.04
K%	0.47	0.49	0.29	0.34
Ca%	0.34	**0.39**	0.32	0.35
Mg%	0.05	0.05	0.05	0.05
S%	0.03	0.05	0.04	0.05
B,ppm	143.74	144.80	144.88	147.40
Cu,ppm	**3.96**	3.40	3.89	3.99
Fe,ppm	**114.62**	80.55	111.60	85.03
Mn,ppm	17.09	**20.60**	13.75	15.47
Zn,ppm	7.78	7.46	6.39	7.33



Bold: significant difference between trunk components. Yellow: significant difference between RSs.

Lazare *et al*. 2021

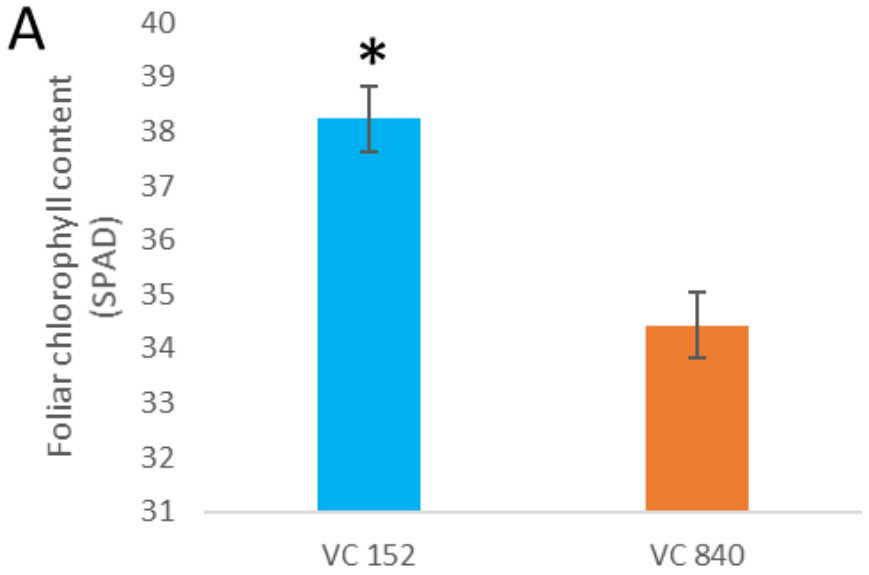
Under salinity

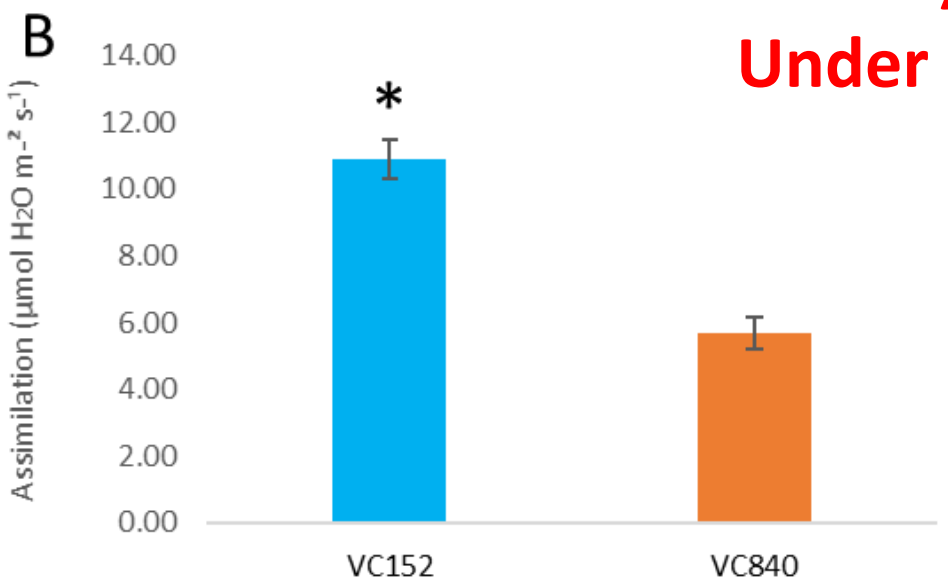


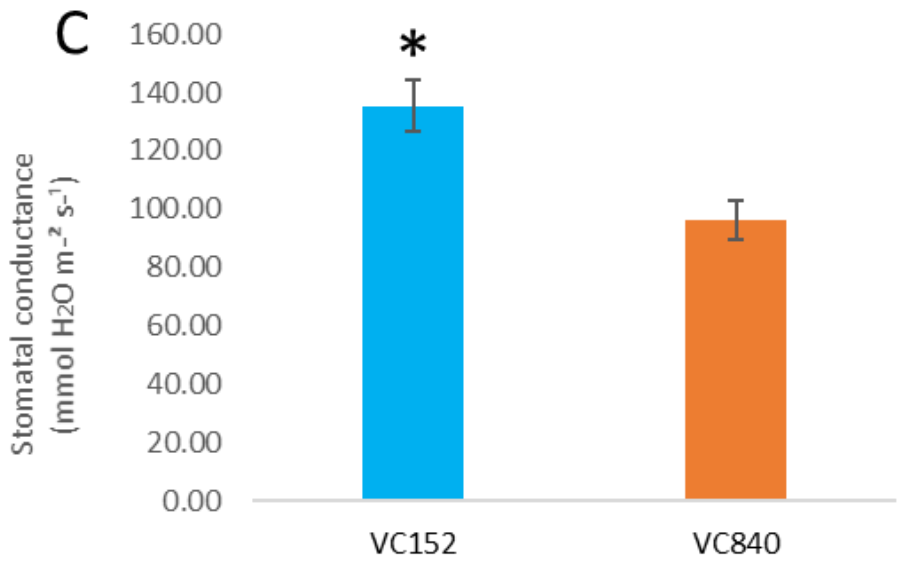
Photosynthesis Under salinity

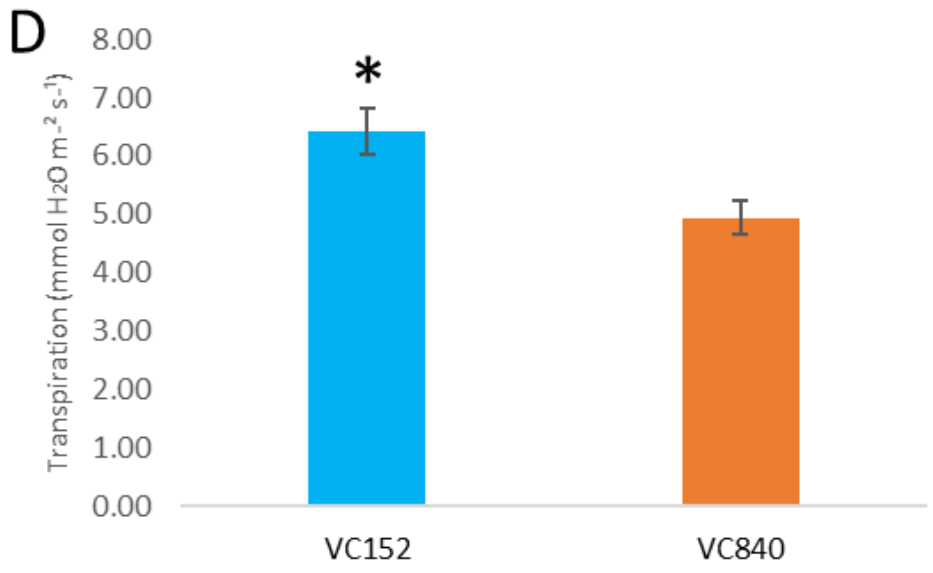
VC840
Sensitive

VC152
Tolerant









The leaves/roots proportion of sugar intensity in each rootstock.

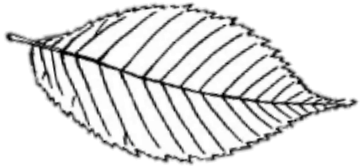
RS	Salinity days	Fructose	Glucose	Sucrose	Mannoheptulose	Perseitol
VC152	0	4.3	35.9	33.4	0.9	1.1
VC840	0	2.4	34.3	61.6	0.8	1.2

RS	Salinity days	Fructose	Glucose	Sucrose	Mannoheptulose	Perseitol
VC152	52	5.4	* 4.5	38.4	* 0.4	1.2
VC840	52	* 10.2	<u>84.9</u>	* <u>114.5</u>	<u>0.9</u>	* <u>2.2</u>

Asterisk (*) represents a significant difference between the salinity treatments.
Underline represents a significant difference between the rootstocks.

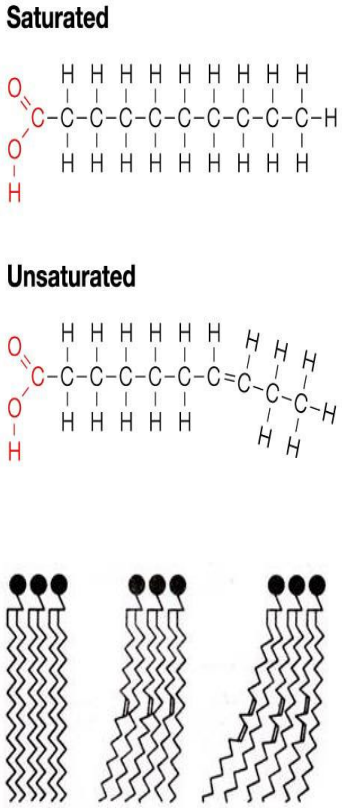
Lazare *et al*. 2021

Lipid profiling of 'Hass' avocado grafted on VC152 or VC840. The effect of salinity exposure (52 days) on the leaves.
Red: increase. Blue: decrease.



Lipid function	VC152	VC840
Storage		
Chloroplasts		
Membranes		

* An increase in the unsaturated forms and a decrease in the saturated ones.

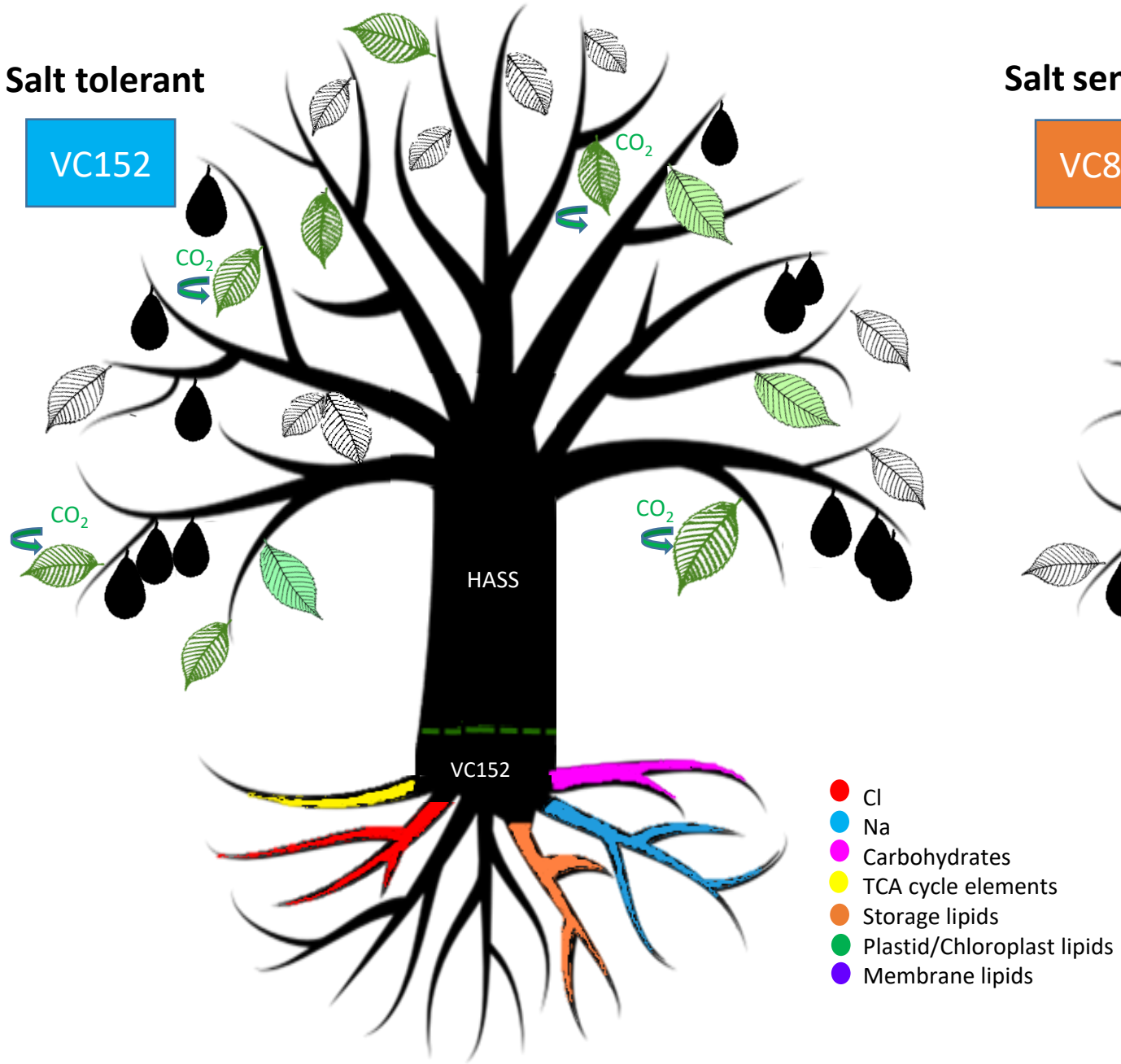


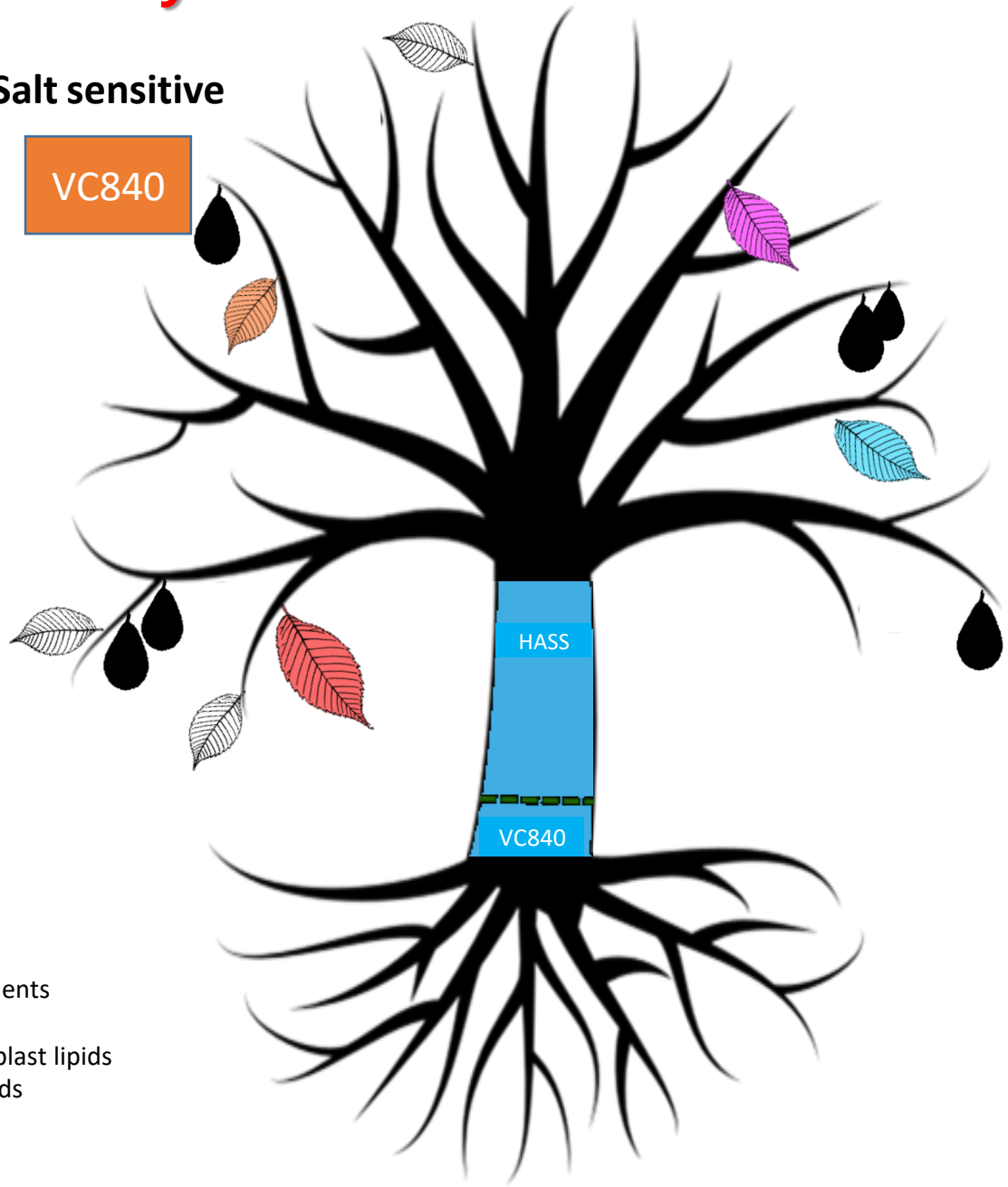
Lipid profiling of 'Hass' avocado grafted on VC152 or VC840. The effect of salinity on roots.
Red: significantly higher in one rootstock over the other.

Function	VC152	VC840
Storage		
Plastids		
Membranes		

Lazare *et al*. 2021

Visual summary





There are reciprocal relationships between RS and scion, and the affinity between them must be considered.

Selecting the right rootstock
is a powerful tool to mitigate
salinity damage
while using low quality water.

Thanks!

Questions are welcomed

Lazare S., Yasuor H., Yermiyahu U., Brotman Y., Ben-Gal A., Dag A. (2021) It takes two: reciprocal scion-rootstock relationships enable salt tolerance in 'Hass' avocado. *Plant Science*

Lazare S., Cohen Y., Goldshtein E., Yermiyahu U., Ben-Gal A., Dag A. (2021) Rootstock-dependent Response of Hass Avocado to Salt Stress. *Plants*

Lazare S., Haberman A., Yermiyahu U., Erel R., Simenski E., Dag A. (2019). Avocado rootstock influences scion leaf mineral content. *Archives of Agronomy and Soil Science*